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(54) METHOD AND APPARATUS OF IDENTIFYING SIMILAR IMAGES

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G06F 17/30 (2006.01)

(52) **U.S. Cl.**
CPC ***G06K 9/6202*** (2013.01); ***G06F 17/30259*** (2013.01)

(58) **Field of Classification Search**
CPC ... G06K 9/6202; G06K 9/46; G06K 9/00442; G06K 9/4633; G06K 9/62; G06F 17/30253; G06F 17/30265; G06F 17/30244; G06F 17/30256; G06F 17/30864
See application file for complete search history.

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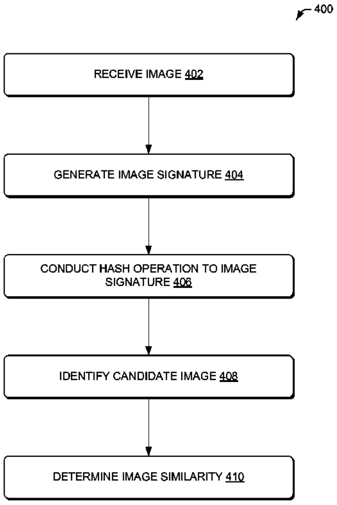
(57) ABSTRACT

A user may submit an image and request from a server one or more images that are similar to the submitted image. The server may generate an image signature based on the content of the submitted image. The server may conduct a Hash operation to the image signature to generate one or more Hash values. These Hash values may be used to identify one or more candidate images similar to the image in a Hash table. These candidate images may be sorted and outputted to the user based on similarity. The similarity between each of the candidate images and the image may be determined using at least one of Hamming distance or Euclidean distance.

14 Claims, 7 Drawing Sheets


400
RECEIVE IMAGE 402
GENERATE IMAGE SIGNATURE 404
CONDUCT HASH OPERATION TO IMAGE SIGNATURE 406
IDENTIFY CANDIDATE IMAGE 408
DETERMINE IMAGE SIMILARITY 410

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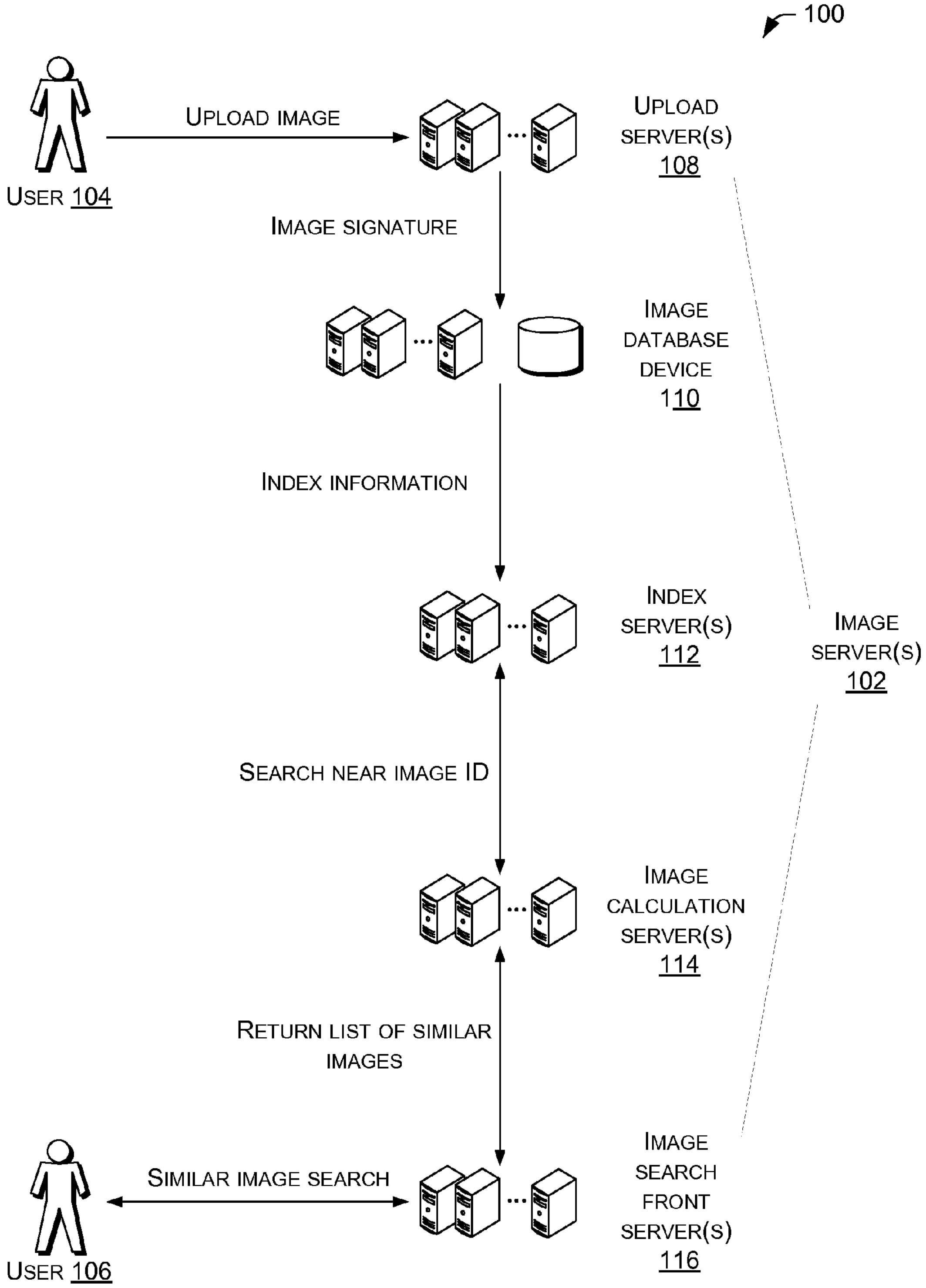
100
USER 104
UPLOAD IMAGE
UPLOAD SERVER(S) 108
IMAGE SIGNATURE
IMAGE DATABASE DEVICE 110
INDEX INFORMATION
INDEX SERVER(S) 112
IMAGE SERVER(S) 102
SEARCH NEAR IMAGE ID
IMAGE CALCULATION SERVER(S) 114
RETURN LIST OF SIMILAR IMAGES
SIMILAR IMAGE SEARCH
IMAGE SEARCH FRONT SERVER(S) 116
USER 106

FIG. 1

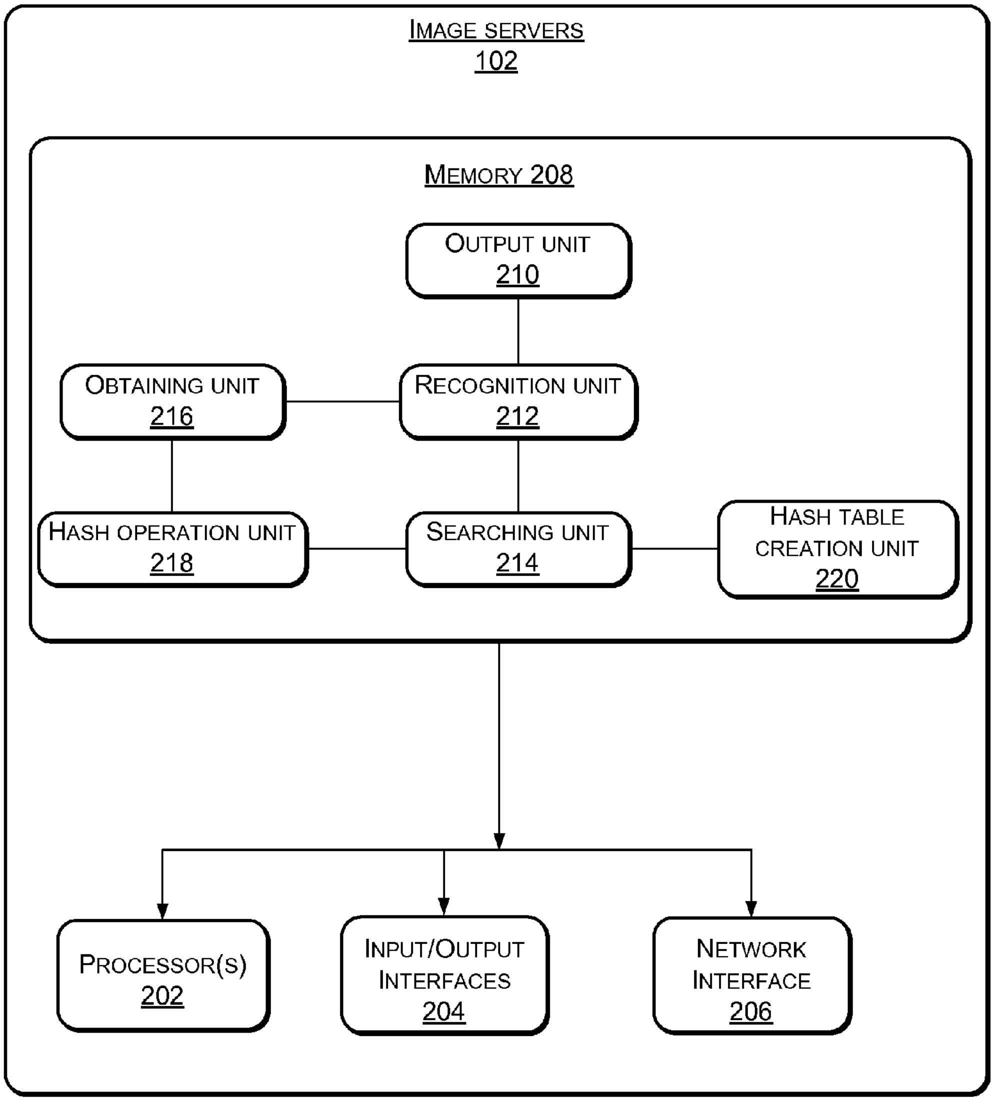
IMAGE SERVERS
102
MEMORY 208
OUTPUT UNIT
210
OBTAINING UNIT
216
RECOGNITION UNIT
212
HASH OPERATION UNIT
218
SEARCHING UNIT
214
HASH TABLE
CREATION UNIT
220
PROCESSOR(S)
202
INPUT/OUTPUT
INTERFACES
204
NETWORK
INTERFACE
206

FIG. 2

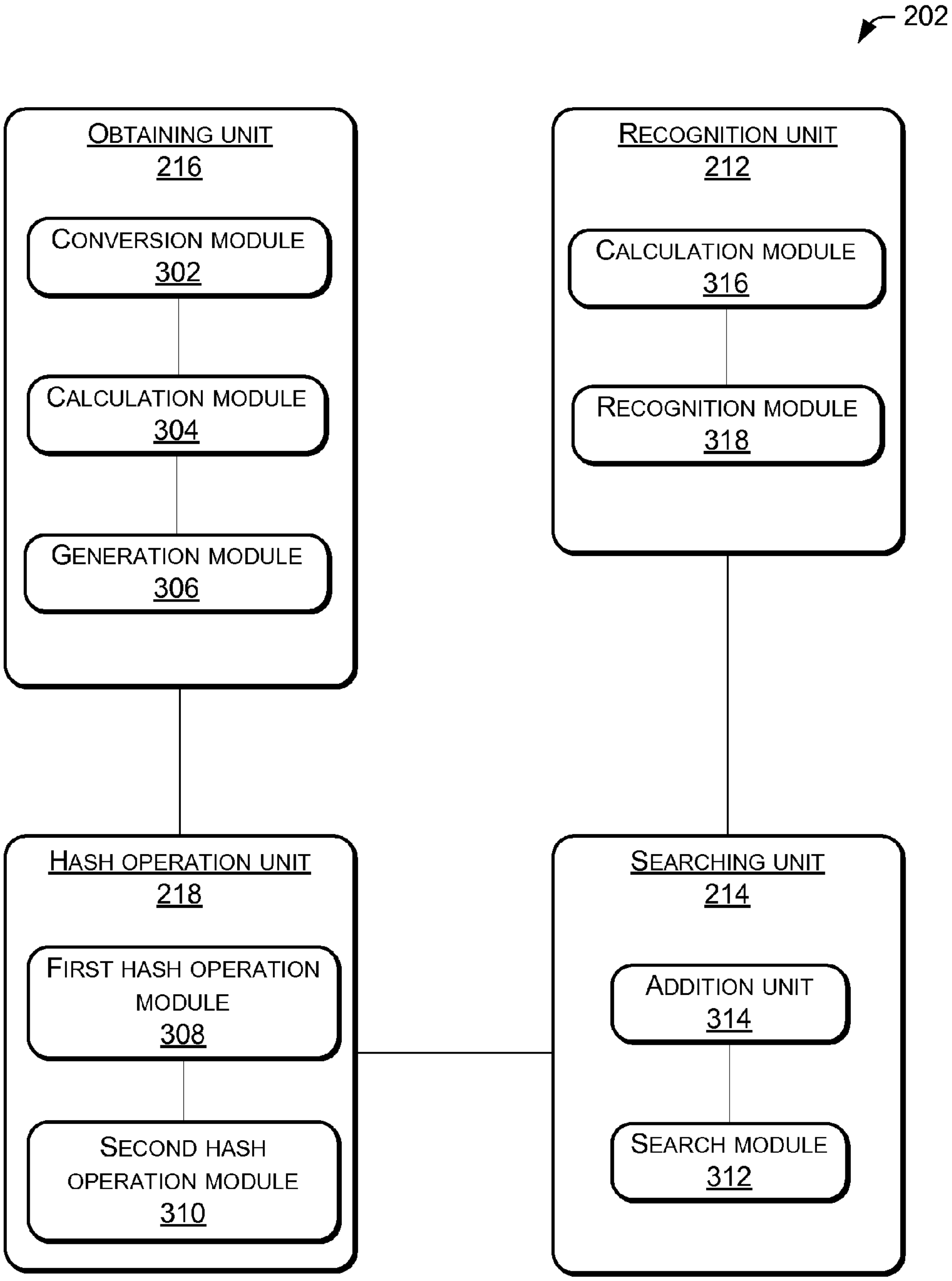
202
OBTAINING UNIT
216
CONVERSION MODULE
302
CALCULATION MODULE
304
GENERATION MODULE
306
RECOGNITION UNIT
212
CALCULATION MODULE
316
RECOGNITION MODULE
318
HASH OPERATION UNIT
218
FIRST HASH OPERATION MODULE
308
SECOND HASH OPERATION MODULE
310
SEARCHING UNIT
214
ADDITION UNIT
314
SEARCH MODULE
312

FIG. 3

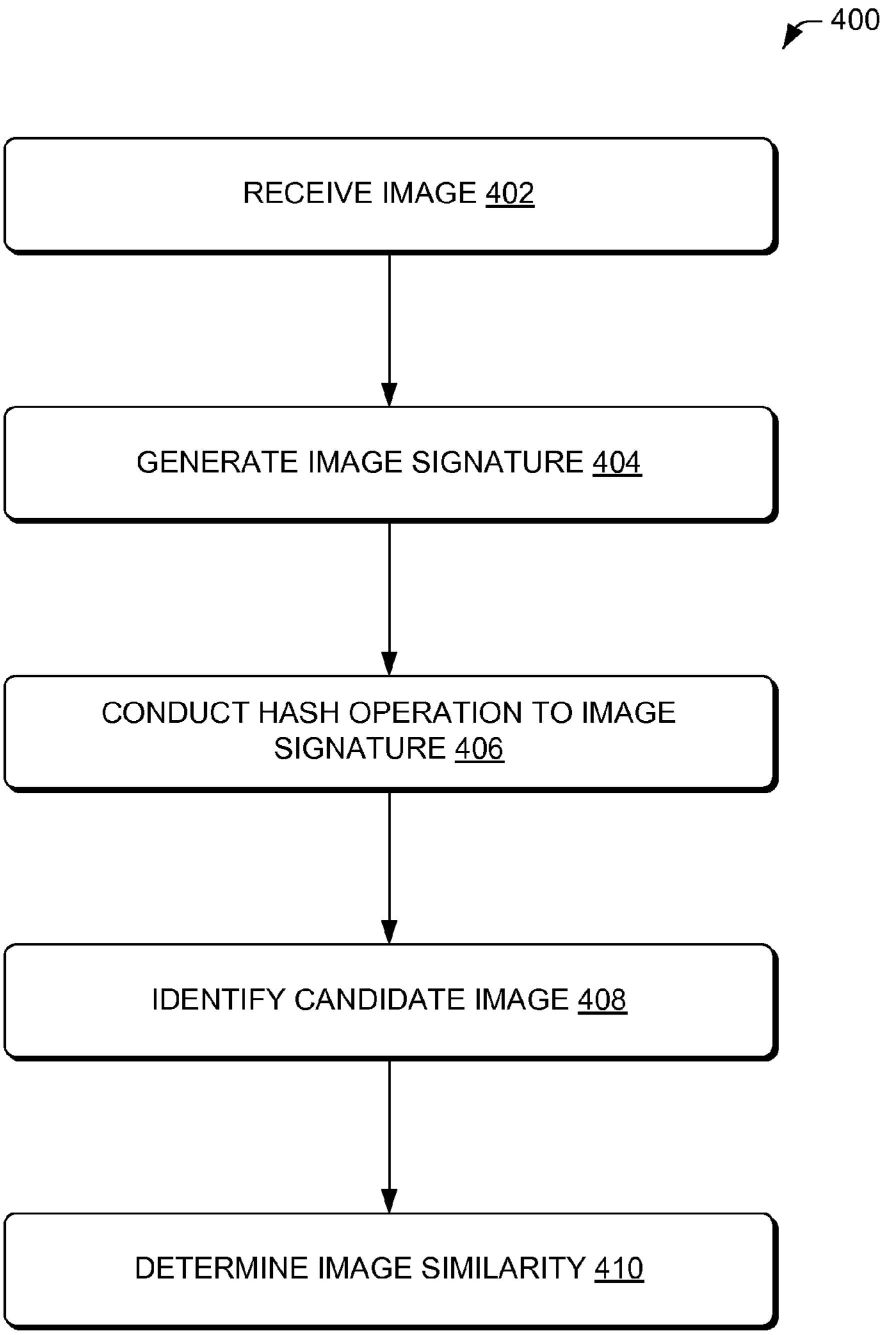
400
RECEIVE IMAGE 402
GENERATE IMAGE SIGNATURE 404
CONDUCT HASH OPERATION TO IMAGE SIGNATURE 406
IDENTIFY CANDIDATE IMAGE 408
DETERMINE IMAGE SIMILARITY 410

FIG. 4

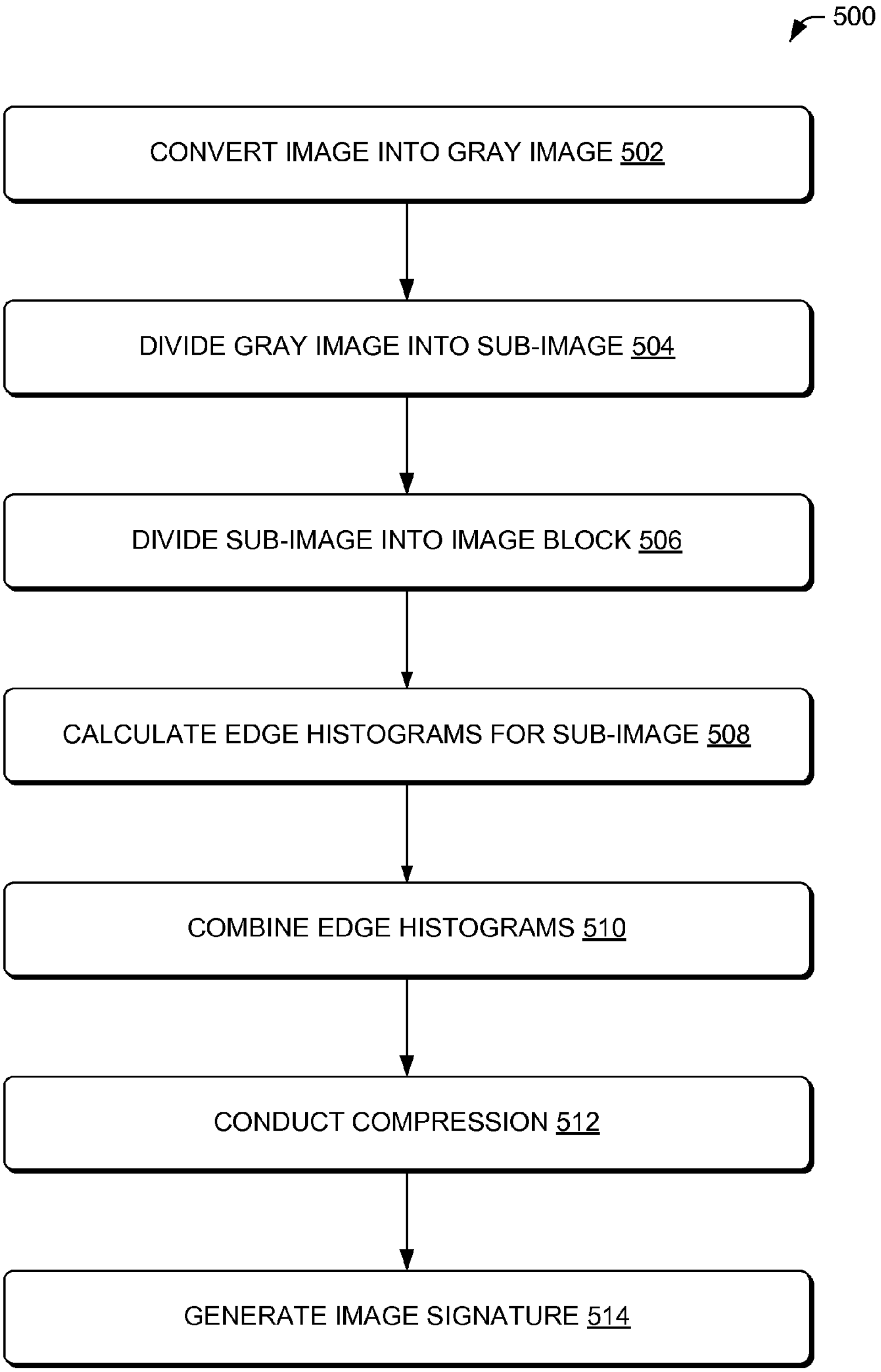
500
CONVERT IMAGE INTO GRAY IMAGE 502
DIVIDE GRAY IMAGE INTO SUB-IMAGE 504
DIVIDE SUB-IMAGE INTO IMAGE BLOCK 506
CALCULATE EDGE HISTOGRAMS FOR SUB-IMAGE 508
COMBINE EDGE HISTOGRAMS 510
CONDUCT COMPRESSION 512
GENERATE IMAGE SIGNATURE 514

FIG. 5

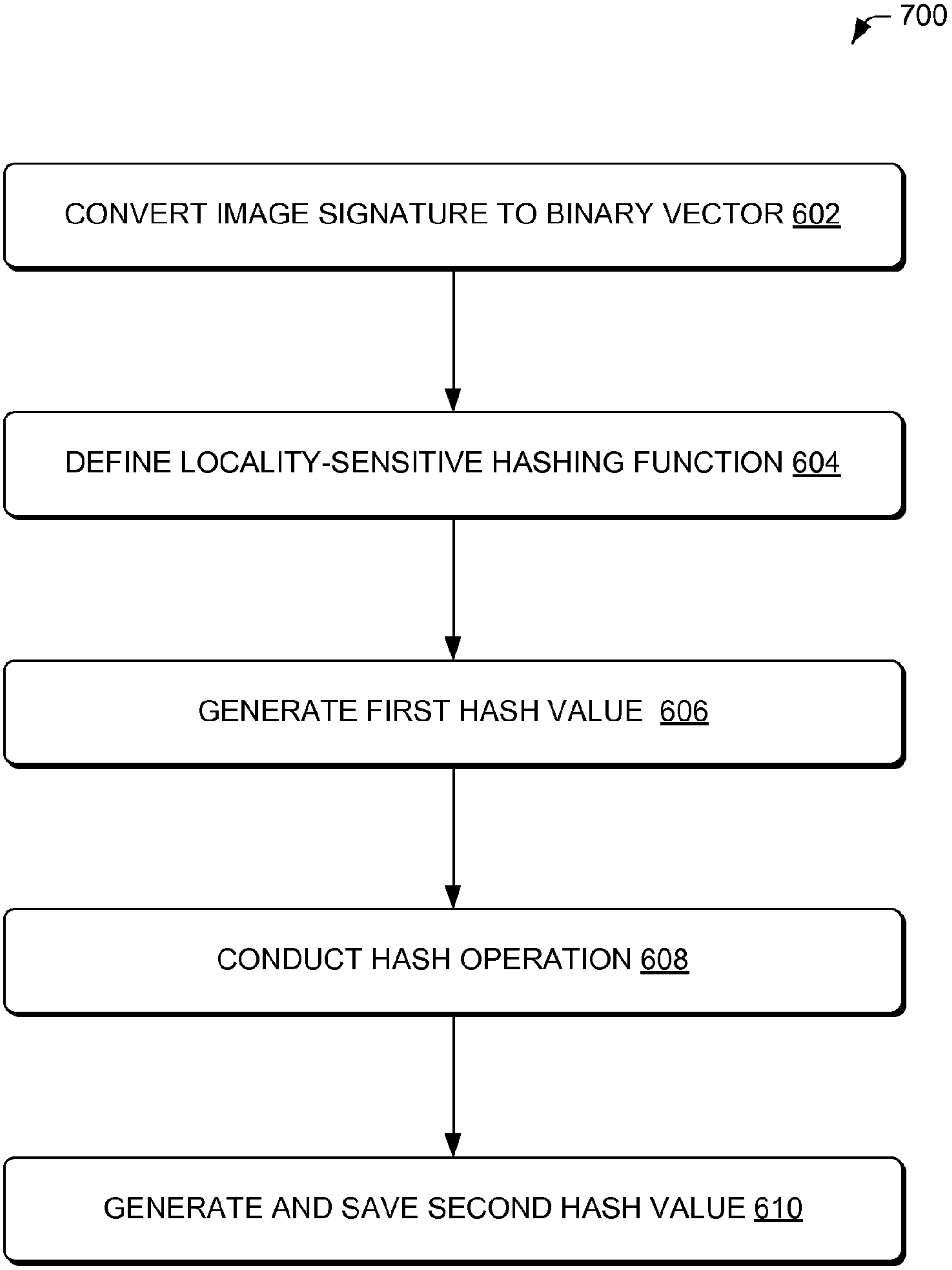
700
CONVERT IMAGE SIGNATURE TO BINARY VECTOR 602
DEFINE LOCALITY-SENSITIVE HASHING FUNCTION 604
GENERATE FIRST HASH VALUE 606
CONDUCT HASH OPERATION 608
GENERATE AND SAVE SECOND HASH VALUE 610

FIG. 6

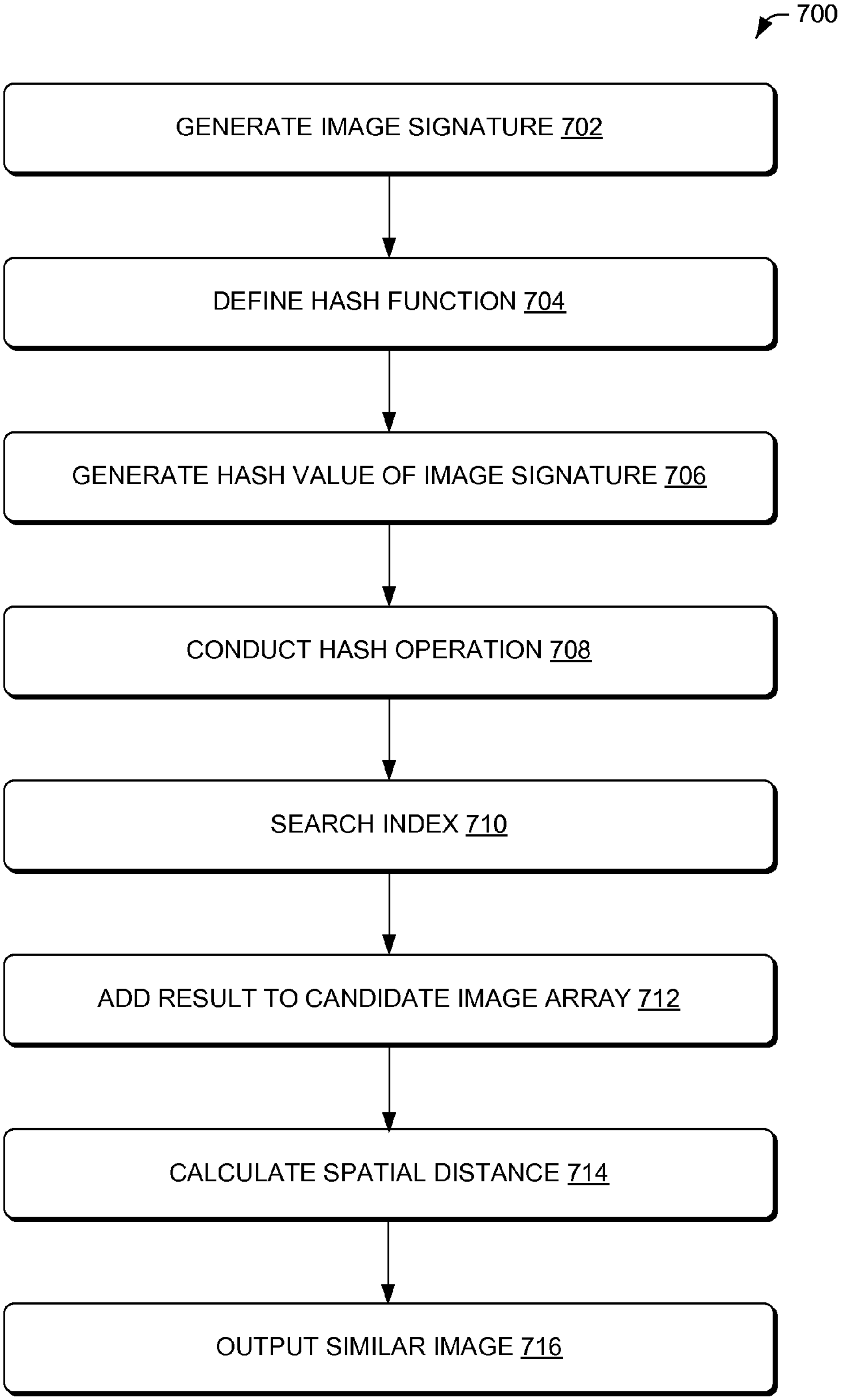
700
GENERATE IMAGE SIGNATURE 702
DEFINE HASH FUNCTION 704
GENERATE HASH VALUE OF IMAGE SIGNATURE 706
CONDUCT HASH OPERATION 708
SEARCH INDEX 710
ADD RESULT TO CANDIDATE IMAGE ARRAY 712
CALCULATE SPATIAL DISTANCE 714
OUTPUT SIMILAR IMAGE 716

FIG. 7

METHOD AND APPARATUS OF IDENTIFYING SIMILAR IMAGES

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

This application is a national stage application of an international patent application PCT/US12/21722, filed Jan. 18, 2012, which claims priority to Chinese Patent Application No. 201110031701.8, filed on Jan. 28, 2011, entitled "METHOD AND DEVICE OF SIMILAR IMAGE RECOGNITION," which applications are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

This disclosure relates to the field of multimedia image recognition. More specifically, the disclosure relates to methods and devices of image recognition.

BACKGROUND

Similar image retrieval, as a type of multimedia recognition technologies, is booming. The similar image retrieval may comprise feature extraction, index construction, inquiries, and similarities sorting. However, conventional technologies of similar image retrieval may present some problems (e.g., poor compatibility and fault tolerance problems) because conventional image signatures do not contain content information of images. For example, two images that have identical content but saved in different formats (e.g., bmp, jpeg, png, or gif) may be considered as different images.

SUMMARY

This disclosure provides methods and devices for identifying similar images. In some embodiments, a user may submit an image and request from a server a set of images that are similar to the submitted image. Upon receiving the submitted image, the server may generate an image signature based on the content of that image. The server may also conduct a Hash operation to the image signature to generate one or more Hash values. The one or more values may be used to identify candidate images similar to the image. The server may then determine an image similarity between each of these candidate images and the image.

In some embodiments, to generate the image signature, the server may convert the image into a gray image and then divide the gray image into multiple sub-images. The server may then calculate edge histograms of each of the multiple sub-images. Based on the edge histograms, the server may generate the image signature. In some embodiments, to generate the one or more Hash values, the server may conduct a Hash operation to the image signature using Locality-sensitive hashing functions to generate one or more first Hash values. The server may then conduct a Hash operation to each of the one or more first Hash values to generate one or more second Hash values. The one or more second Hash values may be used to identify the candidate images. In some embodiments, to determine the image similarity, the server may determine a similarity between the image and each of the one or more candidate images using at least one of Hamming distance or Euclidean distance.

BRIEF DESCRIPTION OF THE DRAWINGS

The Detailed Description is described with reference to the accompanying figures. The use of the same reference numbers in different figures indicates similar or identical items.

FIG. **1** is a schematic diagram showing an exemplary environment for identifying similar images.

FIG. **2** is a schematic block diagram showing an exemplary of the image server(s) of FIG. **1**.

FIG. **3** is a schematic block diagram showing another exemplary of image server(s) of FIG. **1**.

FIG. **4** is a flowchart showing an exemplary process of identifying similar images.

FIG. **5** is a flowchart showing an exemplary process of obtaining an image signature.

FIG. **6** is a flowchart showing an exemplary process of creating an image index.

FIG. **7** is a flowchart showing another exemplary process of identifying similar images.

DETAILED DESCRIPTION

The detailed description of a method of and server for TCP is set forth with reference to the accompanying figures.

FIG. **1** is a schematic diagram showing an exemplary environment **100** for identifying similar images. The environment **100** may include image servers **102** interacting with a user **104** and a user **106**. The image servers **102** may include upload servers **108**, an image database device **110**, index servers **112**, image calculation servers **114**, and image search front servers **116**.

The user **104** may uploads an image to the upload servers **108** to create image index database. The upload servers **108** may calculate an image signature of the image and send the image signature to the image database device **110**. In some embodiments, the image may be obtained from the Internet and saved in the upload servers **108** using a crawler system. In some embodiments, the upload servers **108** may calculate the image signature of the image based on content information of the image, thus reducing probability of a conflict. For example, the content information of the image may include metadata (e.g., color, grain, etc.) instead of a non-byte stream.

The image database device **110** may conduct a Hash operation to the image by using Locality-sensitive hashing (LSH) after receiving the image signature. The resulting values are then sent as index information to the index servers **112**.

The user **106** may send an image to the search front servers **116** and request the image servers to return a set of images similar to the submitted image. The image search front servers **116** may transmit the image to the image calculation servers **114** and request the similar images or a list of the similar images. In some embodiments, an image signature may be generated based on the content information of the image, and then the index servers **112** search for similar images based on the image signature. In some embodiments, the image calculation servers **114** may search the similar images (e.g., IDs) based on Hash values of these similar images on the index servers **112**. For example, the image calculation servers **114** may identify IDs associated with images having the same Hash value as the image. The similar image or a list of similar images may be returned to the image search front server **116** and displayed to the user **106**.

FIG. **2** is a schematic block diagram showing details of exemplary image servers **102** of FIG. **1**. The image servers **102** may be configured as any suitable servers. In one exemplary configuration, the image servers **102** include processors **202**, input/output interfaces **204**, network interfaces **206**, and memory **208**.

The memory **208** may include computer-readable media in the form of volatile memory, such as random-access memory (RAM) and/or non-volatile memory, such as read only memory (ROM) or flash RAM. The memory **208** is an example of computer-readable media.

Computer-readable media includes volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules, or other data. Examples of computer storage media include, but are not limited to, phase change memory (PRAM), static random-access memory (SRAM), dynamic random-access memory (DRAM), other types of random-access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), flash memory or other memory technology, compact disk read-only memory (CD-ROM), digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other non-transmission medium that can be used to store information for access by a computing device. As defined herein, computer-readable media does not include transitory media such as modulated data signals and carrier waves.

Turning to the memory **208** in more detail, the memory **208** may store any number of software modules or units, including an output unit **210**, a recognition unit **212**, a search unit **214**, an obtaining unit **216**, a Hash operation unit **218**, and a Hash table creation unit **220**. The obtaining unit **216** may obtain an image signature of an image submitted by the user **106**. The Hash operation unit **218** may conduct a Hash operation to the image signature. The searching unit **214** may search for candidate images in predetermined Hash tables. The recognition unit **212** may identify and retrieve image(s) similar to the image from candidate images.

In some embodiments, the image servers **102** may determine similarities of images based on image signatures generated from content of the images. For example, the more similar the images are, the more similar their image signatures are. In some embodiments, the similarities may be related to Hamming distance or Euclidean distance. For example, the shorter these distances, the more similar are the images. Accordingly, images that are the same but saved in different formats may have the same image signatures. Also, problems of fault tolerance with the conventional technologies may be resolved.

In some embodiments, the output unit **210** may output the candidate images based on the similarities. In some embodiments, the Hash table creation unit **220** may create L Hash tables by conducting Hash operations to the image signature to obtain L Hash values by using L LSH functions, wherein L is an integer. The Hash table creation unit **220** may also conduct a Hash operation to the L first Hash values to obtain L second Hash values by using an overall Hash function. The Hash table creation unit **220** may record a j^{th} second Hash value, an image identification and an image signature in the j^{th} Hash table, wherein j=1 . . . L.

FIG. **3** is a schematic block diagram showing another exemplary of image servers **300** that may include, similar to the image servers **102** of FIGS. **1** and **2**, the recognition unit **212**, the searching unit **214**, the obtaining unit **216**, and the Hash operation unit **218**.

The obtaining unit **216** may include a conversion module **302**, a calculation module **304**, and a generation module **306**. The conversion module **302** may convert an image submitted by the user **106** to a gray image. The calculation module **304** may then divide the gray image into N×N sub-images, calculate edge histograms from M directions for each of the sub-images, and obtain N×N×M calculation results, wherein N and M are integers. The generation module **306** may assemble the N×N×M calculation results as an N×N×M dimensional vector of the image signature. In some embodiments, non-uniform quantitative technologies based on human eye sensitivity can be applied to the N×N×M dimensional vector. In some embodiments, statistic data of edge histograms may be used as basic features of the image signature. The statistic data combined with the image division and the non-uniform quantitative technologies based on human eye sensitivity may be resolved problems caused by different colors, scales, or partial fuzzy & distortion. In some embodiments, the gray images may be divided into N×P sub-images.

In some embodiments, the calculation module **304** may, for each image block included in a sub-image, calculate a gradient value on each of the M directions. The calculation module **304** may then select one of the M directions that has the greatest gradient value as the direction of the corresponding image block for statistics. The module **304** may further calculate the number of the selected directions for each of the M directions and obtain the statistic value as histograms of the sub-image.

Suppose that a sub-image has 1000 image blocks, and M has 5 directions including A, B, C, D and E (i.e., M=5). Further, suppose that direction A for statistic data are 100 image blocks, direction B has 200 image blocks, direction C has 300 image blocks, direction D has 400 image blocks, and direction E has no image blocks. As a result, the statistics value (i.e., histograms) of the sub-image may be represented by a vector (100, 200, 300, 400, 0).

In some embodiments, the Hash operation unit **218** may include a first Hash operation module **308** and a second Hash operation module **310**. The first Hash operation module **308** may conduct Hash operations to the image signature, and obtain L first Hash values by using L LSH functions, wherein L is an integer. The second Hash operation module **310** may conduct Hash operations to the L first Hash values, and obtain L second Hash values by using an overall Hash function. In some embodiments, a method of mass similar image index based on the LSH technology may be used to reduce complexity of search time to a non-linear level.

In some embodiments, the searching unit **214** may include a searching module **312** and an addition module **314**. The searching module **312** may search an entry recording the second Hash value in the Hash tables. Each entry of the Hash tables records a Hash value and an image identification of an image. Each entry may further include an image signature. The addition module **314** may add an image to the candidate images upon identifying an entry having the second Hash value in the Hash tables. In some embodiments, an i^{th} second Hash value may correspond to an i^{th} Hash table, and i=1 . . . L.

In some embodiments, the first Hash operation module **308** may convert an image signature to a R dimensional binary vector, wherein R is an integer. The first Hash operation module **308** may then generate L LSH functions by using the R dimensional binary vector. For example, each of the LSH functions is generated based on a one-dimensional or multiple-dimensional binary vector of the R dimensional binary vector.

In some embodiments, the first Hash operation module **308** may assign an input parameter of a LSH function as K, randomly select K dimensional binary vector from the R dimensional binary vector, and combine the K dimensional binary vector as a return value of the LSH function, wherein K<R.

In some embodiments, the recognition unit **212** may include a calculation module **316** and a recognition module **318**. The calculation module **316** may calculate a spatial distance between an image signature of a submitted image and an image signature of a candidate image (e.g., Hamming distance or Euclidean distance). The recognition module **318** may then determine a similarity between the candidate image and the submitted image based on the spatial distance. For example, the smaller the spatial distance is, the more similar the candidate image is to the submitted image.

FIGS. **4-7** are flowcharts showing exemplary processes of identifying similar images. The processes are illustrated as a collection of blocks in logical flowcharts, which represent a sequence of operations that can be implemented in hardware, software, or a combination. For discussion purposes, the processes are described with reference to the image servers **102** shown in FIGS. **1-3**. However, the processes may be performed using different environments and devices. Moreover, the environments and devices described herein may be used to perform different processes.

FIG. **4** is a flowchart showing an exemplary process **400** of identifying similar images. The process **400** may be performed by one or more processors of the image servers, which may be inclusive of one or more microcontrollers (MCU) or one or more field-programmable gate arrays (FPGAs).

At **402**, the image servers may receive an image submitted by the user **106** via, for example, a USB transmission interface, a Bluetooth transmission interface, or an Ethernet transmission interface. At **404**, the obtaining unit **216** may generate or otherwise obtain an image signature of the submitted image. For example, the obtaining unit **216** may involve a MCU or a FPGA to calculate the image signature.

At **406**, the Hash operation unit **218** may conduct a Hash operation to the image signature. In some embodiments, the Hash operation unit **218** may include a MCU or a FPGA configured to perform the Hash operations. In some embodiments, the functions performed by the Hash operation unit **218** and the obtaining unit **216** may be implemented by the same processor(s).

At **408**, the search unit **214** may search entries corresponding to a result of the Hash operation in predetermined Hash tables to identify candidate images. At **410**, the recognition unit **212** may recognize an image similar to the submitted image from candidate images corresponding to the entries. In some embodiments, the image calculation server **108** obtains, locally or from third-party equipment, the candidate images based on the IDs of similar images returned by the index server **106**, and recognizes the image similar to the submitted image from the candidate images based on the entries. In some embodiments, the recognition unit **212** may obtain, locally or from third-party equipment, the candidate image based on the ID of the similar images returned by the searching unit **214**, and recognizes the image similar to the submitted image from the candidate images based on the entries.

In some embodiment, the output unit **210** may include a Bluetooth transmission module, an infrared transmission module and/or an Ethernet transmission module to output the identified similar image and to display to the user **106**.

FIG. **5** is a flowchart showing an exemplary process **500** of obtaining an image signature. The process **500** may generate an image signature based on the grain features of edge histograms.

At **502**, the image servers convert an image submitted by the user **106** to a gray image to make final results not sensitive to color and/or light. At **504**, the calculation module **304** may divide the gray image into N×N sub-images. At **506**, the calculation module **304** may further divide each of the sub-images into a fix number of image blocks. The area of each image block depends on the area of the submitted image. At **508**, the calculation module **304** may then calculate edge histograms from one or more directions for each of the sub-images. For example, the calculation module **304** may calculate a gradient value of an image block on five (5) directions to select a direction having the greatest gradient value to be the direction of the image block for statistics. The calculation module **304** may calculate the frequency that each of the 5 directions is selected as the direction for statistics in one sub-image. The frequency may be used as histograms of the sub-image.

Suppose that a sub-image is divided into 1000 image blocks, and the one or more directions include A, B, C, D and E, 5 directions. Further, suppose that direction A is selected as the directions of 100 image blocks for statistics, direction B had 200 image blocks, direction C has 300 image blocks, direction D has 400 image blocks, and direction E has 0 image blocks. As a result, the statistics value (i.e., corresponding histograms) of the sub-image is a vector (100, 200, 300, 400, 0).

At **510**, the generation module **306** may combine the vector of each sub-image to a multiple dimensional vector as the image signature of the image submitted by the user **106**. If N=4, an image signature may be presented as a 4×4×5=80 dimensional vector. In some embodiments, at **512**, a non-uniform quantitative method may be adopted given non-uniform characteristics of human eye sensitivity. The generation module **306** may conduct quantitative compression to, for example, the 80 dimensional vector to achieve better space utilization. For example, an image signature would be approximately 240 bits (i.e., 30 bytes) if 8 digitals between 0-7 for quantitative process are used. The process may save 90% of storage.

At **514**, the image servers **102** may obtain the image signature after the compression process. In some embodiments, the conversion module **302**, the calculation module **304** and the generation module **306** may be implemented in a MCU.

FIG. **6** is a flowchart showing an exemplary process **600** of creating an image index. At **602**, the first Hash operation module **308** may convert a vector obtained in the process **500** to a high-dimensional binary vector (i.e., each dimension is 1 or 0) in a Hamming space. For example, suppose that a one-dimensional vector value is X and the biggest value is C. As a result, the vector presented in a Hamming space is C-dimensional binary vector including X consecutive 1s right after C-X consecutive 0s.

At **604**, the first Hash operation module **308** may define a Hash function G by randomly selecting a K dimensional binary vector from vectors obtained in the operation **602**, and return a value after combining the results. In these instances, the greater the similarity between the vectors is, the greater the probability of generating the same Hash value is.

At **606**, the first Hash operation module **308** may conduct L Hash functions on the high dimensional vector obtained in the operation **602** to reduce errors of the similarity search, wherein L is an integer. At **608**, the second Hash operation module **310** may conduct Hash operations to the results from the operation **606** with the traditional Hash function (e.g., Message-Digest Algorithm 5 (MD5)). At **610**, the second Hash operation module **310** may save Hash results of the operation **608** as keys and unique IDs of image in corresponding L Hash tables, wherein L is an integer. In some embodiments, images with the same image signatures may be saved in the same bin, while images with different image signatures are more likely to be saved in different bins. In some embodiments, the first Hash operation module **308** and the second Hash operation module **310** may be implemented by a same encoding chip or a same MCU.

In some embodiments, because accuracy and recall rates may be dramatically affected by different K and L, a simulation may be conducted for prediction in advance. The image index, supported by appropriate hardware, may be stored in the memory to increase efficiency in searching. In some embodiments, an image index document may be stored in local disks or processed in a way of distribution for a mass sample database.

FIG. **7** is a flowchart showing an exemplary process **700** of identifying similar images. At **702**, the obtaining unit **210** may calculate an image signature of the image submitted by the user **106**. At **704**, the Hash operation unit **218** may define a LSH function based on the image signature. At **706**, a Hash code of the image signature may be calculated using multiple LSH functions that are randomly selected. At **708**, a Hash operation (e.g., MD5) may be conducted to obtained results. At **710**, the searching unit **214** may search L Hash tables using the results obtained in the operation **708** as keys.

At **712**, the searching unit **214** may add candidate images based on the searched results to a candidate image array. At **714**, the recognition unit **212** may calculate a spatial distance (e.g., Hamming distance or Euclidean distance) between each image signature in the candidate image array and the image signature of the image submitted by the user **106**. In some embodiments, the distance may indicate similarity between the candidate image and the submitted image.

At **716**, the output unit **210** may sort and output candidate images based on the distance. In these instances, a number of the image signatures in the candidate array is much smaller than a number of the image signatures in database. Accordingly, the cost of calculation can be greatly reduced while compared with conventional technologies.

In some embodiments, the Hash operation unit **218** may be a MCU or a FPGA. In some embodiments, the functions operated by the Hash operation unit **218** and the obtaining unit **216** can be implemented by a same processor. In some embodiments, the searching unit **214** may communicate with database through an internal bus, and the searching unit **214** and the recognition unit **212** may be implemented by a same MCU.

In this disclosure, an image signature may be determined based on content of the image. Similarity of image signatures depends on similarity of image content. For example, the more similar two images are, the more similar their image signatures are. The similarity may be represented by a spatial distance (e.g., Hamming distance or Euclidean distance). Therefore, two identical images but saved in different formats may have the same image signatures, resolving the fault tolerance problem existing in the conventional similar image recognition technologies. The disclosure also introduces methods of creating a mass similar image index based on a LSH Hash technology. The methods may reduce complexity of search, save time to a non-linear level, and sort and output results based on similarities. The disclosure also provides edge histogram statistics as a basic feature of the image signature, an image division and the non-uniform quantitative technology based on human eye sensitivity.

The embodiments in this disclosure are merely for illustrating purposes and are not intended to limit the scope of this disclosure. A person having ordinary skill in the art would be able to make changes and alterations to embodiments provided in this disclosure. Any changes and alterations that persons with ordinary skill in the art would appreciate fall within the scope of this disclosure.

What is claimed is:

1. A computer-implemented method for identifying similar images, the method comprising:

receiving an image;

generating an image signature of the image based on content of the image;

conducting one or more first Hash operation(s) to the image signature using one or more Locality-sensitive hashing (LSH) functions to generate a result of one or more first Hash values;

conducting a second Hash operation to the result of the first Hash operations, thereby conducting the second Hash operation to each of the one or more first Hash values, to generate one or more second Hash values;

identifying, in one or more Hash tables, one or more candidate images based on the one or more first Hash values or one or more second Hash values; and

determining an image similarity between the image and each of the one or more candidate images.

2. The computer-implemented method as recited in claim **1**, wherein the generating of the image signature comprises:

converting the image into a gray image;

dividing the gray image into one or more sub-images;

calculating edge histograms from multiple directions for each of the one or more sub-images; and

generating the image signature based on the edge histograms.

3. The computer-implemented method as recited in claim **1**, wherein the identifying of the one or more candidate images comprises identifying based on the one or more second Hash values.

4. The computer-implemented method as recited in claim **3**, wherein the one or more Hash tables included one or more entries, each entry including at least one of a Hash value, an image identification of one image, or an image signature of one image, and each of the one or more second Hash values corresponds to one of the one or more Hash tables.

5. The computer-implemented method as recited in claim **1**, wherein the conducting of the one or more first Hash operations comprises:

converting the image signature to a binary vector having a plurality of dimensions;

generating one or more LSH functions based on the binary vector such that each of the one or more LSH functions is generated based on at least one of a single dimension binary vector of the binary, or a multiple dimension binary vector of the binary vector; and

conducting the one or more first Hash operations to the binary vector by using the one or more LSH functions.

6. The method as recited in claim **5**, wherein the generating of the one or more LSH functions comprises:

assigning a certain number to each input parameter of the one or more LSH function, the certain number being lower than a number of the plurality of dimensions; and

selecting a binary vector having the certain number of dimensions from the binary vector to generate a return value for each of the one or more LSH functions.

7. The method as recited in claim **1**, further comprising:

conducting the one or more first Hash operations to an image signature of each of the one or more candidate images to generate one or more third Hash values based on the one or more LSH functions;

conducting the second Hash operation to each of the one or more third Hash values to generate one or more fourth Hash values; and

recording each of the one or more fourth Hash values, a corresponding image identification, and a corresponding image signature in a corresponding Hash table.

8. One or more servers comprising:

memory;

one or more processors coupled to the memory;

an obtaining unit configured to:

receive an image, and

generate an image signature of the image based on content of the image;

a Hash operation unit configured to conduct a Hash operation by executing operations to:

conduct one or more first Hash operation(s) to the image signature using one or more LSH functions to generate a result of one or more first Hash values, and

conduct a second Hash operation to the result of the first Hash operations, thereby conducting the second Hash operation to each of the one or more first Hash values to generate one or more second Hash values;

a searching unit configured to identify, in one or more Hash tables, one or more candidate images based on the one or more Hash values; and

a recognition unit configured to determine an image similarity between the image and each of the one or more candidate images.

9. The one or more servers as recited in claim **8**, wherein the obtaining unit is configured to generate the image signature by executing operation to:

convert the image into a gray image;

divide the gray image one or more sub-images, and

calculate edge histograms from multiple directions for each of the one or more sub-images; and

generate the image signature based on the edge histograms.

10. The one or more servers as recited in claim **8**, wherein the searching unit is configured to identify the one or more candidate images by identifying, based on the one or more second Hash values, the one or more Hash tables including one or more records that each include at least one of a Hash value, an image identification of one image, or an image signature of one image.

11. The one or more servers as recited in claim **8**, wherein the Hash operation unit is configured to conduct the one or more first Hash operations by executing operations to:

convert the image signature to a R dimension binary vector, the R being a fixed integer;

generate one or more LSH functions based on the R dimension binary vector, each of the one or more LSH functions being generated based on at least one of a single dimension binary vector of the R dimension binary vector, or a multiple dimension binary vector of the R dimension binary vector; and

conduct the one or more first Hash operations by using the one or more LSH functions.

12. The one or more servers as recited in claim **11**, wherein the Hash operation unit is further configured to generate the one or more LSH functions by:

assigning K to each input parameter of the one or more LSH function, the K being another fixed integer and lower than R; and

selecting K dimension binary vector from R dimension binary vector to generate a return value for each of the one or more LSH functions.

13. The one or more servers as recited in claim **8**, further comprising a Hash table creation unit configured to:

conduct one or more third Hash operations to an image signature of each of the one or more candidate images to obtain one or more third Hash values based on the one or more LSH functions; and

conducting a fourth Hash operation to each of the one or more third Hash values to obtain one or more fourth Hash values; and

recording each of the one or more fourth Hash values, a corresponding image identification, and a corresponding image signature in a corresponding Hash table.

14. One or more computer-readable media encoded with instructions that, when executed by a processor of a server, perform acts comprising:

receiving an image;

generating a multiple dimension vector indicating an image signature of the image based on edge histograms associated with the image;

conducting a first Hash operation to the image signature to generate a result of a first Hash value using a LSH function that is defined based on the multiple dimension vector;

conducting a second Hash operation to the result of the first Hash operation, thereby conducting the second Hash operation to the first Hash value using Message-Digest Algorithm to generate a second Hash value;

retrieving from a Hash table one or more candidate images based on the second Hash value; and

determining a similarity between the image and each of the one or more candidate images using at least one of Hamming distance or Euclidean distance.

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